COAL PILLAR EXTRACTION BY CONTINUOUS MINER USING FISH AND TAIL METHOD – A CASE STUDY

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Abstract - Opencast mining is the most prevalent method for coal extraction in India. Since underground coal mining requires high technical expertise, higher gestation period and higher capital investments, therefore opencast mining is more preferred for extracting coal deposits at shallow to moderate depths. In the last three decades, there has been a considerable increase in the production from opencast mines fulfilling over 80% of the country's demand for coal. As a result, underground coal mining is still contributing only 15-20% production from 70% underground coal reserves. Most of the thick coal seam is found at greater depth and use of conventional method of underground mining is proved to be less efficient in giving a large production. The government is considering a push for underground mining to extract deep-seated coal to boost coal production but is facing challenges of resources and lack of machinery. One of the ways that can boost underground coal mining is through a piece of equipment called a continuous miner. It requires less investment and can work in difficult conditions, even in the absence of a long stretch of continuous deposition. This paper discusses the Mass Production Technology used in Pinoura Mines of Johilla area of South Eastern Coalfields Limited with depillaring by Fish and Tail method using Continuous Miner.

Keywords - Coal mining, Continuous miner, Depillaring, Fish and Tail

I. INTRODUCTION

The demand of coal in India for electricity production and in domestic as well as heavy industries such as Steel & Cement is increasing year after year. The world is striving towards cleaner energy sources but India being a developing country and behind in terms of technology to harness renewable energy resources such as Solar & Tidal energy, is poised to increase its coal production exponentially in the coming years. To meet this increased demand, a broad spectrum mechanization in underground mines is required with due regard to the cost of production, productivity, profitability and safety. Since around 70% of country's coal reserve is amenable to be worked by underground methods, the industry needs to turn towards heavy mechanization to bridge the demand-supply gap. Underground coal mining in India is done mainly by Longwall and Board and Pillar method. The applicability and success of longwall method in Indian coal mines is very limited and few which can be applied to only virgin coal seams. The mechanization of mine with this method is very capital intensive. Whereas, Continuous Miner technology with Bord & Pillar method is a more viable option which can be applied to both virgin and developed coal seams. This technology helps in faster extraction of coal with increased safety with low capital. Since most underground mines in India have been developed by Bord & Pillar method, this method can meet out the desired production. This paper discusses the success story of deployment of Continuous Miner for coal extraction in the Pinoura Mine of Johilla area of South Eastern Coalfields Limited. The method of pillar extraction and the equipment details are presented in the paper.

II. COAL EXTRACTION USING CONTINUOUS MINER

Bord and Pillar mining is one of the widely preferred methods of coal extraction in India. Prior to the development of continuous mining technology, the mining cycle was composed of undercutting the coal, drilling, blasting and loading. This non cyclic method suffers from poor productivity. With the introduction of continuous miners in bord and pillar method, all the unit operations are performed continuously. The extent of improvement in productivity is governed by geomining conditions, sequence of extraction, cutout distance, support requirements and deployment of compatible transport system.

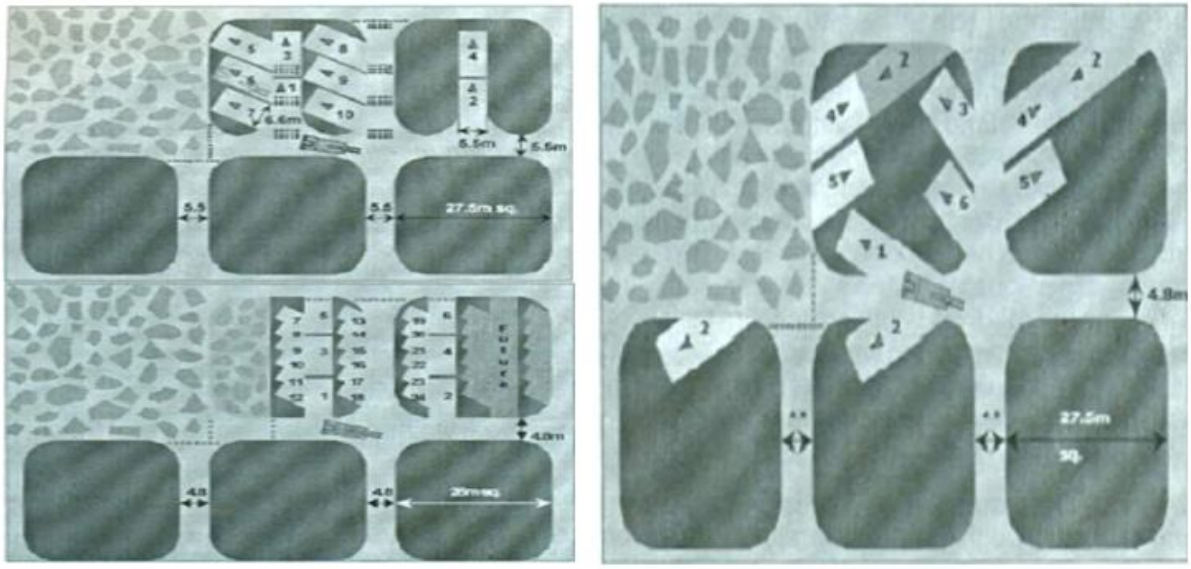
Continuous miners consist of large rotating steel drum equipped with tungsten carbide teeth that scrape coal from the seam. Continuous miners are generally used in combination with shuttle cars to transport the extracted coal from the face to a transfer point (feeder breaker). From there the coal is typically tipped onto the underground conveyor system and taken to the surface.

After development of pillars in the Bord and Pillar method consideration has to be given to the extraction of coal pillars; which is known as pillar extraction or depillaring. In the process of pillar extraction, the extraction line should be so arranged as to facilitate roof control. Diagonal line or step diagonal line of extraction is commonly followed. In special cases, a steep diagonal line of face or even straight line of face are also used. Diagonal or step diagonal line of

face provides protection as the working places are supported by solid pillars and also when the roof caves, there is less risk of goaf flushing into the working faces. It is also claimed that diagonal line of extraction helps in the caving of the roof. Pillar extraction using continuous miner is carried through different methods. The prominent methods which are:

2.1 Split and fender method

In this method, the extraction of coal is carried out in a sequence of cuts through the pillar parallel to dip to form two fenders (wings) of coal. The roof with in the split shall be supported with roof bolts. Fenders are extracted from the split and original gallery with additional supports as shown in figure 1 (a).



(a) Split and fender method (b) Nevid method

Figure 1 Methods of depillaring by continuous miner

2.2 Nevid method

In this method the pillars are mined by continuous miner from the original level and dip galleries continuous miner cuts on either side of pillars from original gallery. Thus a solid stump of mid portion of the pillar leaves by cutting around it as shown in figure 1 (b).

2.3 Fish & Tail Method

The method involves extraction of coal by cutting slices using continuous miner in level direction first and then driving a push out in the dip direction. A straight line of extraction of pillars is maintained during the extraction of coal and sequence is so adopted to allow the caving of the roof in the dip direction. The details of the method including sequence of pillar extraction is described in succeeding section of the paper.

III. CASE STUDY

Pinoura mine in Johilla area (Umaria Coalfields), South Eastern Coal Fields Ltd. is located at Umaria district of Madhya Pradesh. According to Geological Survey of India reserves of non-coking coal up to a depth of 300 m in Umaria Coalfield is approx. 181.29 MT. The coal seams of the area are of lower Permian stage and occurring as barker formation. The middle portion of this formation contain all the coal seams. The soil and alluvium thickness varies from 0 to 8 m. The strike of the coal bearing formation is ENE-WSW in eastern part while almost to the east-west in the western part of the block.The dip of the coal seam in the eastern part is 5° to 6° (gradient to 1 in 11). In the northern part, dip reduces to 4° to 5° (gradient 1 in 12). In the western part also the dip is found to be 4° to 5°. A total of 17 faults (F1 to F17) have been deciphered in Pinoura block. Total six coal seams viz. Local II, Local – 1C, 1B, 1A, Johilla bottom and top have been identified in this block area (Table 1). Total geological reserve of Johilla Bottom and Local 1-B seam having thickness more than 1.2 m is 19.82 MT. Out of which, 3.1 MT reserve is in Johilla bottom seam and that of 16.72 MT in local 1-B seam. Johilla (top) seam is the topmost and Llocal-II is the bottom most seam. Except Johilla Bottom and Local-1B seam, all other seams are thin seams and developed in patch. A brief details of these seams are as follows:-

Johilla (top) Seam:

Prevalent seam thickness vary in between 0.2m to 0.75m and grade of coal is B/F. Developed in isolated patches and does not offer economic potentiality in the mine.

Johilla (Bottom) Seam:

The parting vary in between Johilla top and bottom is 11.08m to 22.07m. Immediate roof of the seam is shale/sandstone intercalation and floor is fine to medium grained sandstone. Prevalent thickness ranges is 1.2m to 1.8m and has 1.257 MT extractable reserves.

Local-1A seam:
It is a thin seam and has been developed workable thickness of more than 0.9m in small area in central part only. The parting with Johilla bottom seam is 17.12m to 30.38m and it does not have economic potentiality.

Local – 1 B seam:
This is most potential seam in this block. Parting with Johilla bottom seam vary in between 17.49m to 39.47m. Inmajor part, immediate roof is curb shale/fine grained sandstone and floor is shale carb, shale/sandstone intercalation. It has prevalent thickness range of 3.0m to 4.0m, the grade of coal is 'C'. Presently the mine is working in this seam. The extractable reserves available for further extraction, within the proposed mine area, is 7.054 MT.

Local – 1c seam:
It is the second seam from the bottom and occurs 2.6m to 5.5 m below local-IB seam/ it is thin seam in major part of the area and inferior grade coal i.e. E/F and does not have mining potentiality.

3.1 Details of Mechanization
The details of mass production equipment deployed at the mine are discussed here.

3.11 Continuous Miner
The cutting drum has a width of 3.5 m and diameter of 1.2 m with 61 Teeth or cutting bits. The cutting bits are present at the end of picks made up of Tungsten- Carbide. There are fifteen Water spray nozzles are present to suppress dust and the exhaust helps in control of dust further. Two Circular Loading arms are present at the bottom to collect the broken the coal onto the chain conveyor. The chain conveyor discharges the coal onto the ram`car or shuttle car. The loading process is completed in approximately 72 sec. The make, specifications and dimensions of the continuous miner deployed in the mine is presented in Table 2.

3.12 Coal Hauling by Ramcar
Diesel operated ramcar is used to haul the coal from discharge end of Continuous Miner to the Feeder Breaker arrangement. It is powered by a 230 HP engine which uses 37.5 l/hr of diesel and has the capacity to haul 14 tons of coal at a time. The general specification of the ram car is presented in Table 3.

3.13 Dispatch of ROM to Surface
Ramcar unloads all the coal onto the Feeder Breaker which crushes it down to smaller pieces for its easy transprotation. These broken coal is further transported to the main bunker using belt conveyors. The whole system is electrically powered and is operated at 1.1 kV by a motor of power 150 kW. The specifications of the same is presented in Table 4.

3.14 Front Bucket Loader (FBL 10)
It is a multi-utility vehicle with 3.5 m3 ejector bucket attached with it. The general specifications of Front Bucket Loader is presented in Table 5.

3.15 DBT Dual Boom Roof Bolter
DBT Dual Roof Bolter is Electrohydraulic, selfpropelled, mast feed, dual head roof control drill. Its drillheads are mounted on extending, swinging and lifting booms. General specifications of the Roof Bolter are as given in Table 6.

Operating Dimensions		**Transport Dimensions**	
Maximum Mining Height	4660 mm (With 350 mm Ground Clearance & 1168 mm Drum	Height	1836 mm (With 4.8 CU M/S Dust Collector & Dual Inlet)
Zero Cutting Clearance	2074 mm (With 350 mm Ground Clearance & 1168 mm Drum)	Overall Length	11286 mm (With 1168 mm Cutting Drum)
Ground Clearance	350 mm (Fixed)	Main Frame Width	3175 mm (Without Cutter Head & Gathering Pan)
		Weight (Total)	65 Tonnes
Cutting Unit		**Loading Unit**	
Cutting Drum Diameter	1168 mm	Loading Method	3 Arm Replaceable Tip Circular Loading Arm (CLA)/ 62 rpm
Cutting Drum Width	3505 mm	Gathering Pan Width	3346 mm
Cutting Head Power	2 X 186 kW Continuous Rating / 2 X 210 kW 1 hr Rating	Loading Capacity	15 to 27 tonnes per min
Number of teeth	61 (Tungeston carbide bits with spray nozzles for water spraying)	Conveyor Speed	145 m/min

Table 2: Specifications of Contiuous Miner (DBT 30M4-NP (Narrow Profile)

Capacities		**Engine**	
Payload (Max with hungry boards)	15 m3	Type/Make	Diesel, Turbo Charged, after cooled, 4 Cycle/ Caterpillar 3126
Payload (Maximum)	20,000 kg	Displacement/ Maximum power	7.6 litre/171.5 kW (230 hp) @ 2600 rpm

Table 3 Specifications of Ram Car

Overall length	34’ 61/2” (10,528 mm)	Level hopper capacity	440 ft³(12.46 m³)
Overall width	10’ 4” (3,149 mm)	Capacity (w/ optional 12” sideboards)	530 ft³ (15 m³)
Receiving height (min.):	13” (330 mm)	Weight	70,000 lbs (31,752 kg)
Discharge height (max.)	53” (1,346 mm)	Material input size (max.):	2’ x 3’ x 4’ (607mm x 914 mm x 1,219 mm)
Operating height (max.):	78” (1,981 mm)	Discharge rate (max.)	1,200 TPH @ 135 fpm (41 m/min)

Table 4: Specifications of feeder breaker

Overall Length	10,528 mm	Breaker Speed	67 RPM
Overall Width	3,149mm	Drive Motor-	150kW/1140v/AC/50Hz/TEFC
Operating Height (Max)	1,981 mm	Tram Speed	14.33 m/min
Drive Motor	Radial Piston Hydraulic Low Speed High Torque		

Table 5: Specifications of Front Bucket Loader

Dimensions and Operating parameters			
Length	7,200 mm	Maximum Operating Gradient (uphill)	14º
Minimum Operating Height	2,100mm	Maximum Operating Gradient (downhill)	14º
Maximum Operating Height	5,000mm	Rib Drilling	4,000 mm
Maximum Climbing Gradient	14º	Minimum Roadway Width for Angle Rib Drilling	3,500 mm

Table 6: Specifications of roof bolter

The details of Systematic Support Rule of the Pinoura Mine is discussed below:

During development the roof of gallery, 4.8 m wide gallery was supported by installing roof bolts of length 1.5m utilizing the cement capsule. In each row of support 4 bolts were driven into the roof at a spacing of 1.2 m with each other and 0.6 m from the wall. The distance between two consecutive rows was kept 1.2 m. During Depillaring operation the gallery is widened by use of Continuous Miner to 6.5 m and additional roof bolts are installed by use of Roof Bolter. These bolts are 1.8 m long and utilize Resin Capsule. Roof Bolt is followed by a square bearing plate after which a Dome Washer is placed and finally a Nut is installed for providing support to the roof as shown in Fig.1. Junction is supported by installation of 2.4 m long bolts by Roof Bolter in Star Pattern as shown in Fig.2. A bolt is installed in the central from which at a distance of 1m, eight other bolts are installed. The distance of the outer bolt with Breaker line is 1 m. If required, junction may also be supported with chock support if the condition of the roof strata is very bad. Breaker line (as shown in Fig.2) which is considered to be the most successful supporting technique to separate the goaf area from working area is present at 2 m away from central bolt of Star Support. Breaker line has two rows of 7 bolts of length 2.4 m each. The spacing between two consecutive bolts is 1 m and between wall and bolt is 0.25 m. Indicating prop (Policeman) made of

Eucalyptus Wood and Tell Tales are installed to keep an eye on roof condition and check its dilation.

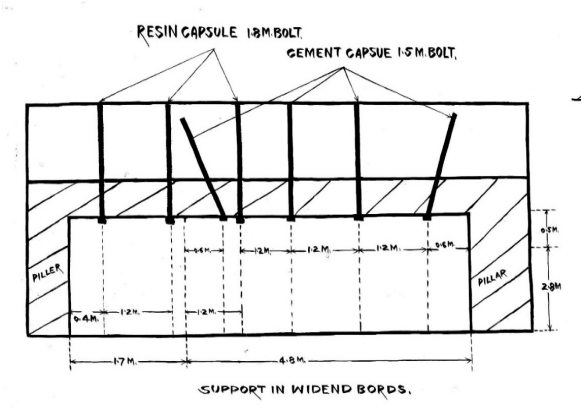


Fig 2 Resin & Cement Capsule (Support in Widened Bords)

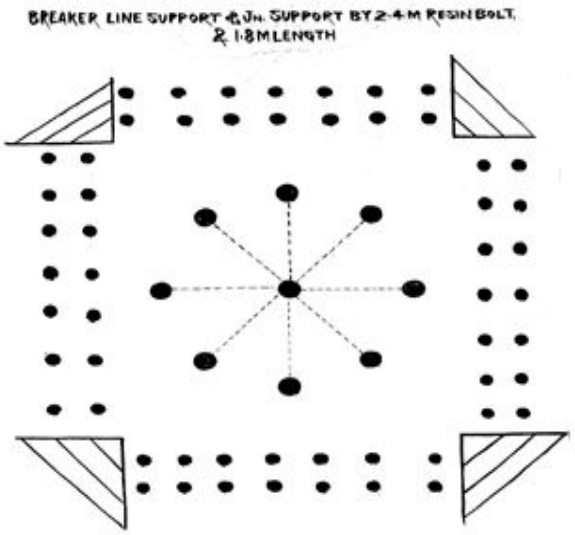


Fig. 3. Breaker Line & Junction Support

3.2 Method of Pillar Extraction

The depillaring is done by Fish & Tail Method which involves extraction of coal by cutting slices using continuous miner in level direction first and then driving a push out in the dip direction considering the Systematic Support Rules along the roadways. A straight line of extraction of pillars is maintained during the extraction of coal and sequence is so adopted to allow the caving of the roof in the dip direction.The dimensions of first two slices are 8.1 m in length & 3.5 m in width for pillar of size 14 x 14 mfrom center to center. The first slice is cut after leaving 2.5 m of coal to support from the edge. Similar slice is again cut with continuous miner with 60 degree inclination from the working level. The next slice is made with a width of 1.2m for the optimum utilization from the coal pillar. Similar pattern of extraction is done from the opposite side of extracted slices with similar dimensions of slices and clearly shown in Fig.2. After the slices are cut, a push out is made from the dip at same angle from dip direction. The push out is driven after leaving 4.9 m of coal support from one edge and 4.8 m of coal support from the opposite edge at the same angle from the dip direction.

Total tonnage of coal present in one pillar is 877.52 tons and tonnage of coal removed by extraction using continuous miner is 584.13 tons. So, the net percentage recovery from one pillar is 66.65%.

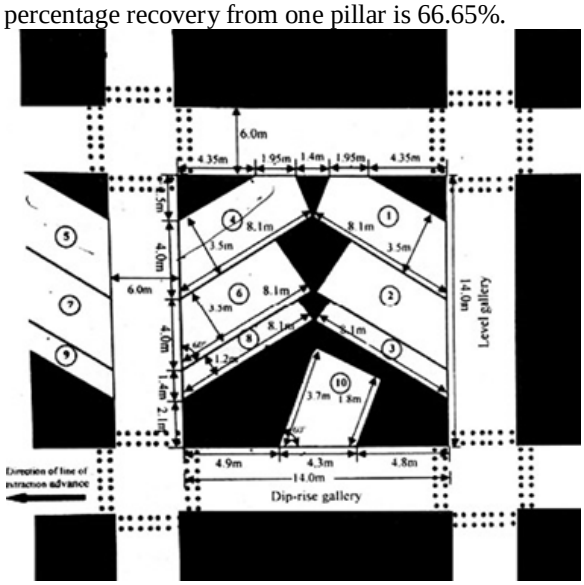


Fig. 4. Extraction Pattern in Fish & Tail Method

CONCLUSIONS

Mass production technology not only increases the production but also offers increased safety through remote controlled operation. Elimination of blasting operation improves the overall working and environment at the face. The paper discusses the Fish & Tail Method of pillar extraction by continuous miner. The method gives an increased percentage recovery and better roof control against other depillaring methods such as Nevid method and Split & Fender method.

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